Loudness and annoyance of infrasound

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Published in:
Proceedings of International Conference on Noise Control Engineering, Internoise '81, Amsterdam, October 6-8, 1981

Publication date:
1981

inter·noise 81

LOUDNESS AND ANNOYANCE OF INFRASOUND.

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INTRODUCTION

It is a well known fact that infrasound at high level is audible, and several investigations indicate that it may also cause annoyance. The annoyance seems to be extremely dependent on the level, e.g. a small increase in sound pressure level may give a large increase in annoyance. This can be explained if the loudness curves run very close in this frequency region, and if the annoyance is related to the loudness sensation. This investigation deals with determination of equal loudness contours down to 2 Hz. It also includes determination of subjective nuisances and effects on blood pressure from 8 and 16 Hz pure tones.

SUBJECTS

15 students (8 female and 7 male) between 18 and 25 years were used as subjects. All 15 participated in the annoyance experiment, and 14 (7 female and 7 male) participated in the loudness measurements. The subjects threshold of hearing were within ±10 dB of the normal threshold at the octave frequencies 125 Hz to 8 kHz.

LOUDNESS MEASUREMENTS

Loudness measurements are normally done by comparisons with 1 kHz reference tones. Because of the large difference in quality of a 1 kHz tone and the infrasound tones a supporting point at 63 Hz was used in this investigation. For each person the comparison of 1000 Hz and 63 Hz was done in an anechoic room with 1000 Hz as the reference tone. Then the 63 Hz tone was used as reference for comparisons with 31.5, 16, 8, 4 and 2 Hz. The latter took place in an infrasound test chamber. The whole procedure was carried out for 20, 40, 60, 80 and 100 phon.

The psychometric method used for the measurements was the Method of Maximum Likelihood (MML). This method provides a very fast and re-

liable determination of points of equal sensation. The setup used a computer to optimize presented levels, manage the presentations, indicate status of the run for the experimenter and write and punch the results for documentation. Thus the measurement of a single point was carried out automatically.

Results. For the 14 subjects the set of equal loudness curves were determined. For each point the mean value was calculated and results are shown in figure 1.

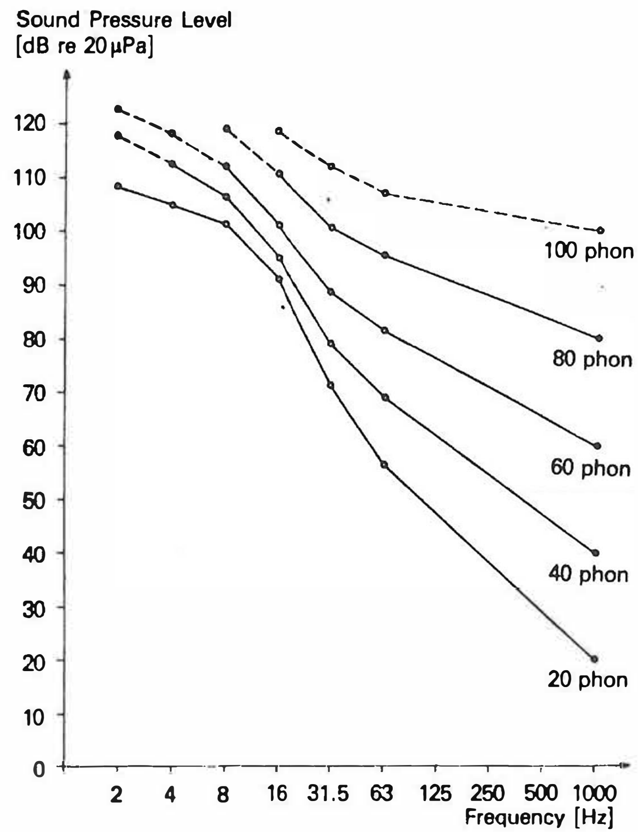

Figure 1. Mean values of the curves of equal loudness (phon curves). Due to power limitations it has not been possible to determine all points for all subjects. In case of missing points at the upper end a similar number are removed from the lower end in order not to bias the results in a lowering way. Points based on less than 14 subjects are indicated by dotting of the line.

BLOOD PRESSURE AND SUBJECTIVE EFFECTS.

The following sound stimuli were used:

A:	16 Hz	110 dB
B:	16 Hz	100 dB
C:	8 Hz	110 dB
D:	8 Hz	120 dB
E:	Silence	

The subjects were exposed twice to the 5 stimuli, each exposure being 20 minutes, followed by a 10 minutes break. This resulted in a 5 hour experiment in which the subjects participated three at a time. In order to balance out possible fatigue and learning effects a randomized double latin square design for the exposures was used.

In the breaks blood pressure was measured and a questionnaire with 10 questions about the subjective impressions during the preceding exposure was filled out. Each question was followed by a vertical line, at the bottom labelled "not at all" and at the top "really much" except for question 9, where labelling was "hardly audible" and "very loud". Answers were given with a cross at the line where the subject felt his answer could be represented. All positions were allowed.

Results. The blood pressure values, and from the questionnaires, the distance to the crosses from the bottom of the line expressed in percent of total line were treated in a 2-way analysis of variance. The independent variables were 1) person and 2) sound exposure. The obtained significance levels are shown in table I.

	Significance of 2-way interaction	main effects person	main effects exposure
a)			
Systolic blood pressure	-	< 0.001	-
Diastolic blood pressure	-	< 0.001	-
b)			
1. Have you had a headache?	-	< 0.001	-
2. Did the noise annoy you?	0.036		
3. Did you feel nervous?	-	< 0.001	-
4. Did you feel tense?	-	< 0.001	-
5. Did you feel pressure on your ear?	0.020		
6. Did you feel tired?	-	< 0.001	-
7. Did you feel nausea?	-	< 0.001	-
8. Did you feel dizzy?	-	< 0.001	-
9. How would you rate the noise?	0.098		
10. Did the noise irritate you?	-	< 0.001	< 0.001

Table I. Significance of main and interaction effects for the results from a) blood pressure measurements and b) questionnaires. Only significance levels below 0.1 are indicated. When 2-way interaction is significant, no main effects are considered.

Blood pressure. As expected a significant dependency of the person is seen. However, no effects from the sound stimuli are present, neither as a main effects nor as interaction effects.

Questionnaires. In three questions 2-way interaction effects are significant. This means that the exposure has an effect, and this effect is not the same on all persons. This is the case in question 2, 5 and 9. As reactions are individual, main effects are dependent on the group of subjects. For the present group mean values are shown in table II. Also in table II mean values are given for question 10, where a main effect from the exposure was significant.

	Sound exposure A	B	C	D	E
2. Did the noise annoy you?	35	14	19	32	5
5. Did you feel pressure on your ears?	29	10	12	30	9
9. How would you rate the noise?	58	30	28	57	5
10. Did the noise irritate you?	39	15	17	38	4

Table II. Mean values of answers to questions that have shown significant interaction effects or main effects for sound exposure.

It is quite obvious that the exposures A and D caused the largest "amount" of annoyance, ear pressure, loudness and irritation. B and C represented lower "amounts" while E can be regarded as a "zero". The nuisances asked for in the other questions (headache, nervousness, tense, tiredness, nausea, dizziness) did appear in some degree, but they were not significantly changed by the sound stimuli.

DISCUSSION

In the present experiment a number of nuisances were shown to be caused by infrasound at 8 and 16 Hz. The nuisances had a character that could relate them to the awareness of the sound (annoyance, pressure on the ear, rating of noise, irritation). This seems to support the supposition that loudness is important when evaluating infrasound. Correlation analysis between loudness and the indicated nuisances are expected to be presented at the conference.

Blood pressure and indirect nuisances (headache, nervousness, tense, tiredness, nausea, dizziness) showed no influence from the sound stimuli. This may be because of a complete lack of influence at the present levels, but it may also be because of the short exposures and the short time between them, thus causing interaction between exposures.

AKNOWLEDGEMENTS.

This project was supported by "Rockwools Lydpris".